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ORIGINAL ARTICLE

A randomized controlled trial of the effect of school food and dining room modifications on classroom behaviour in secondary school children

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Background/Objectives: Adequate nutrition is considered important for learning, but there is little robust research on the association between diet and learning in school-aged children in industrialized countries. This study investigated the effect of tailored modifications to the food and dining experience in secondary schools on learning-related behaviours.
Subjects/Methods: In 2008, 12 co-educational secondary schools in England were recruited. Schools were randomly allocated to receive a tailored action plan and support to modify their food provision and dining environment over a 15-week period (intervention or to control). Learning-related behaviours were systematically observed during post-lunchtime classes at all schools. Observations were made by trained observers using a validated protocol to determine whether pupils were 'on-task' (concentrating and alert) or 'off-task' (disruptive or disengaged).
Results: In total, 156 pupils were observed (control $n=58$, intervention $n=98$) at baseline (12 210 and 20 560 observations, control and intervention, respectively) and at follow-up (16 846 and 23 462, respectively). On-task and off-task behaviours were similar across treatment groups at baseline. At follow-up, intervention group pupils were 18% more likely to be on-task (odds ratio (OR) 1.18, 95% confidence interval ((95% CI) 1.05–1.33) and 14% less likely to be off-task (OR 0.86, 95% CI 0.75–0.98) compared with control group pupils.
Conclusions: This study suggests that modifying food provision and the dining environment can improve learning-related behaviours of secondary school pupils in the post-lunch period. This finding supports ongoing investment and interventions by local authorities across the United Kingdom to improve school food and lunchtime dining facilities.
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Introduction

In the United Kingdom, as elsewhere, the alarming increase in childhood obesity has prompted investigation of the factors that encourage optimal nutrition in children and young people. The 'ecological model' of obesity suggests both micro and macroenvironments as mediators of food choice and nutrient intakes (Swinburn *et al.*, 1999; Foresight, 2007). The school microenvironment provides an ideal setting to introduce food competencies associated with the curricular development of skills and knowledge and to facilitate the development of healthy food preferences, choices and cultures. In England, the introduction of some of the most stringent and comprehensive regulations for school food and nutrient intakes is changing the face of school food through measures at the macrolevel (The Education Regulations, 2007, 2008; Harper *et al.*, 2009). These standards not only ensure that the school lunch offered is nutritionally balanced but also that they have been introduced with substantial guidance and support for local authorities to implement and sustain the necessary changes (Golley and Clark, 2007). Schools in England are, therefore, an appropriate platform for the investigation of the effect of school food interventions on health, behaviour and learning outcomes.

Most published research on diet and educational performance or attainment relates to the levels of malnutrition

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observed in developing countries. Although indicative of the benefits of providing a healthy diet, these findings cannot be generalized to developed countries. It is widely believed that children who are fed well learn well. This is supported by cross-sectional evidence that food insufficiency is positively associated with poorer academic, cognitive and psychosocial development in children and young people even in the developed world (Alaimo *et al*., 2001). A recent systematic review of published controlled intervention trials ($n=69$ studies) of dietary change in school-aged children in developed countries concluded that there was insufficient evidence to identify a specific effect of nutrition on learning, education or performance (Ells *et al*., 2008). Criticisms of existing published research included the lack of high-quality, generalizable research using robust, systematic and repeatable methodologies and interventions of sufficient duration.

Published intervention studies have mainly investigated the effect of nutrient supplements and the presence/absence and content of the breakfast meal on a range of subjective and objective learning outcomes (Dickie and Bender, 1982; Meyers *et al*., 1989; Southon *et al*., 1994; Wolraich *et al*., 1994; Rampersaud *et al*., 2005; Dalton *et al*., 2009; Micha *et al*., 2010). Few studies have addressed the relationship between school lunch consumption and educational outcomes (Gietzen and Vermeersch, 1980; Kim *et al*., 2003; Florence *et al*., 2008; Selvik Ask *et al*., 2010) and no study has focussed on classroom behaviour in the post-lunchtime period. The present study redressed this by investigating the effect of a catering and dining room intervention in secondary schools on classroom behaviour in the post-lunchtime period using a validated, systematic, direct observational methodology. This observational protocol, developed by Blatchford *et al.* (2006), has previously been used in a similar study by our group (Golley *et al*., 2010). That study demonstrated a significant improvement in productive classroom interactions such that primary school children attending intervention schools were 3.4 times (95% confidence interval (95% CI) 1.56–7.36) more likely to be 'on-task' than controls in the post-lunchtime period. Data from a randomized controlled trial of the effect of dining and food interventions on the classroom behaviour of secondary school pupils are reported here; nutritional data will be published separately.

Materials and methods

Study design

In January 2008, all the co-educational secondary schools in four local authority areas representing the diversity of socioeconomic characteristics observed in England (Manchester, Sheffield, Leicester and Essex) were approached and invited to participate in a school lunch and behaviour study. Respondent schools were eligible to participate if they had the need and capacity to improve both food provision and the dining environment. Schools that had recently upgraded dining facilities, were unable to undertake one or the other arms of the intervention or could not provide a dedicated study coordinator were not eligible to participate.

Three co-educational secondary schools, matched on key social and school level factors, were identified in each of the four local authorities. Within each triplet of schools, two schools were randomly allocated to receive the intervention and one school to wait-listed control.

Interventions. A food and dining room checklist tool developed for the Primary School Study (Golley *et al*., 2010) was used to develop practical intervention activities that were based on recent experience and best practice. This provided a framework for schools to implement a tailored and flexible intervention plan that was underpinned by a consistent process.

Food interventions aimed to improve pupils' food choices and nutrient intakes and included a range of activities such as modifying menus to comply with the food-based standards and promote those menus to parents and children.

Dining room interventions aimed to improve the dining experience and involved both temporal and physical changes including staggering lunch times and modifying the layout and queuing system.

The interventions included in the work plan for each school are presented in Table 1.

Intervention schools received £2000 towards the costs of making the planned changes to the food and dining environment. Control schools were offered the intervention including the same financial support at the end of the 15-week study period.

Systematic observations of classroom behaviour

Observer training and interobserver reliability. Fieldworkers, from the National Centre for Social Research, underwent an initial 4-day intensive training programme on the behavioural observational schedule, which included *in situ* practice. This was followed by weekly support sessions throughout the baseline data collection period and refresher sessions immediately before the follow-up phase. Interobserver reliability based on the synchronized coding of six observers for 100 observations at four locations were 'good' to 'excellent' (guidelines from Fleiss, 1981) for the classroom observations, with κ-coefficients averaging at time one 0.70 (minimum 0.65, maximum 0.78) and at time two 0.69 (minimum 0.53, maximum 0.83).

Subject observations. Schools were instructed to randomly select seven consenting pupils from each participating year group (years 7 and 9) for observation. To observe each child during post-lunchtime classes over a school week, observations were made by three observers (one per class). This was the most efficient way of collecting data on selected pupils

Table 1 Summary of interventions undertaken by each intervention school

Intervention	*School*						
	1	*2*	*3*	*4*	*5*	*6*	*7*
Nutrition-based interventions							
Menu refined to meet food-based standards for school lunch	✓	✓	✓	✓	✓	✓	✓
Menus advertised to parents and pupils, e.g. in classrooms, in the dining room, on plasma screens, as leaflets, on internet and in school newsletter	✓	✓	✓	✓	✓		
Meal deals introduced (special price for main meal, dessert and drink)	✓	✓	✓		✓		✓
Tasting session for pupils			✓	✓			✓
Taster pots available at point of service	✓		✓				✓
Themed food days	✓		✓		✓		✓
Healthy eating week			✓			✓	
Free school meals advertised to parents e.g. via poster, letter, open evening	✓	✓	✓		✓	✓	✓
Halal food introduced			✓		✓		✓
Salad bar introduced					✓		
Software/standardized recipes acquired to work towards complying with nutrient-based standards	✓			✓	✓		✓
Freely available water introduced in to the dining room	✓			✓	✓		
Food labelling introduced	✓		✓		✓		✓
Environment-based interventions							
Dining room re-painted		✓					
Art work/murals put in the dining room		✓		✓	✓	✓	
Flow assessment of dining to reduce queuing times		✓	✓		✓		
Serving counters re-organized/extra dining space introduced to reduce queuing			✓	✓	✓	✓	
Tables re-arranged to increase flow-through of pupils in the dining room	✓	✓	✓				
Stay-on-site policy introduced							✓
Code of conduct for the dining room introduced				✓			✓
Peer supervisors/role models used to give pupils ownership of lunch service		✓	✓				
Sign up to Million Meals[a]	✓	✓	✓	✓	✓	✓	✓
Work towards Healthy Schools status[b]	✓						✓
Cookery club established						✓	

[a]The Million Meals Campaign is a resource developed by the School Food Trust to facilitate schools to increase the take-up of school meals.
[b]The National Healthy Schools Programme is a joint initiative between the United Kingdom Department for Children Schools and Families and the Department of Health—which promotes a whole school/whole child approach to health.

during concurrent classes. Pupils were observed in classes across the sciences, arts and humanities.

Observation schedule. The observation schedule involved recording the time spent in different work settings (individual, pupil–pupil interaction, adult-led group, whole class, pupil plenary, others), teaching topics and social modes (interacting with their teachers, interacting with other pupils, not interacting (working individually)) (Blatchford *et al*., 2006). The behaviour of the target child was the focus for all observations irrespective of whether he/she was interacting with other pupils or adults. Observations of each target child were made over a 5-min period in 10 sets of 30 s blocks.

For the purposes of addressing the research question, observations were processed and the following judgements made:

The target child was considered to be 'on-task' (concentrating and alert) if he/she was engaged in behaviour relevant to the activity in which the teacher and other adults in the class expected the pupil to be engaged.

The target child was considered to be 'off-task' (disruptive or disengaged) if he/she was engaged in behaviour that was unrelated to the activity in which the teacher and other adults in the class expected the pupil to be engaged.

Statistical analysis. The odds ratio (OR) for each of the binary outcomes was estimated using multilevel logistic regression to account for the hierarchical structure of the data (Goldstein, 1995). To account for the differences at baseline between the control and intervention groups, the reported ORs, with an associated 95% CI, reflected the interaction between time point and experimental group and were adjusted for potential confounders including class size, presence of additional adults in the classroom (yes/no), English as an additional language, free school meal eligibility, gender, special educational need status, ethnicity (White British or 'other') and lunch type (school lunch or packed lunch). All analyses were performed using MLWiN, version 2.02 (Rasbash *et al*., 2005).

Statistics in the text and tables are reported as ORs, each with an associated CI and *P* value. Outcome events were coded so that an OR above 1.0 indicated a beneficial effect of the experimental intervention.

Results

Pupil characteristics

A total of 156 pupils (control $n = 58$, intervention $n = 98$) participated in the study. At baseline, treatment groups were balanced with respect to key characteristics including sex, age, free school meal entitlement and special educational needs; by chance, there were fewer pupils with English as an additional language in the control group.

Observations

At baseline, 12 210 observations were made of control pupils and 20 560 of intervention pupils. At follow-up, 16 846 and 23 462 observations were made of control and intervention pupils, respectively, providing adequate power to detect differences between groups. The numbers of observations for each time point, stratified by treatment group and social mode, are shown in Table 2.

Learning behaviours

The primary outcome was the effect of intervention on classroom on-task and off-task behaviours across the three social modes (individual target, working alone; pupil–pupil interaction, target pupil interacting with another pupil; teacher–pupil interaction, target pupil interacting with teacher), as well as for total on-task and total off-task behaviours. As shown in Table 2, baseline total levels of on-task (attentive/engaged) behaviours were high in both control and intervention groups (79.1% and 82.1%, respectively), whereas total levels of off-task behaviours (unengaged) were low in both groups (16.5% control and 14.0% intervention). At the follow-up assessment, on-task behaviour had increased and off-task behaviour had decreased in both groups, but the changes were significantly greater in the intervention group.

Both the unadjusted and adjusted models suggest a significant time–treatment interaction for total on-task and total off-task behaviours. As shown in Table 3, intervention group pupils were 18% more likely to be on-task than were control group pupils (OR = 1.18, 95% CI 1.05–1.33) and 14% less likely to be off-task than control group pupils (OR = 0.86, 95% CI 0.78–0.98) at the end of the intervention period. Examination of pupil behaviour across social modes suggested that most of the improvements in task-related behaviours resulted from pupils working better on their own. Pupils tended to be less on-task and more off-task when interacting with a teacher, but this did not reach statistical significance.

Table 2 Number of observations[a] and percentage of time spent in specified activities, by social mode and intervention group, at baseline and post-intervention

	Baseline				*Post-intervention*			
	Control		*Intervention*		*Control*		*Intervention*	
	n	%	n	%	n	%	n	%
On-task behaviour								
Individual								
On-task	2315	85.6	3280	85.7	2690	89.6	3636	90.2
Not on-task	389	14.4	546	14.3	312	10.4	396	9.8
Pupil–pupil								
On-task	1416	67.5	2739	74.0	2739	73.9	3653	79.4
Not on-task	681	32.5	964	26.0	965	26.1	948	20.6
Teacher–pupil								
On-task	1561	82.6	3344	89.3	2408	84.5	3537	87.1
Not on-task	329	17.4	402	10.7	443	15.5	525	12.9
Total								
On-task	4831	79.1	8440	82.1	6825	81.0	9986	85.1
Not on-task	1274	20.9	1840	17.9	1598	19.0	1745	14.9
Off-task behaviour								
Individual								
Off-task	346	12.8	482	12.6	269	9.0	353	8.8
Not off-task	2358	87.2	3344	87.4	2733	91.0	3679	91.2
Pupil–pupil								
Off-task	495	23.6	810	21.9	800	21.6	773	16.8
Not off-task	1602	76.4	2893	78.1	2904	78.4	3828	83.2
Teacher–pupil								
Off-task	235	12.4	278	7.4	331	11.6	392	9.7
Not off-task	1655	87.6	3468	92.6	2520	88.4	3670	90.3
Total								
Off-task	1000	16.4	1439	14.0	1263	15.0	1391	11.9
Not off-task	5105	83.6	8841	86.0	7160	85.0	10340	88.1

[a]There is the possibility of the co-occurrence of teacher–pupil and pupil–pupil contexts (that is, these two contexts are not mutually exclusive). This situation may happen, for example, when a teacher is leading a reading group, when the teacher is talking to the class while a student is simultaneously talking to another student and so on.
The total number of off-task and not-off task in the two sections of the table are not the same because 'not on task' includes various 'off-task' variables PLUS other variables (in this study procedure, social and other).

Discussion

This study shows that modifying food provision and dining environments has the potential to improve learning-related behaviours of secondary school pupils in the post-lunch period. The finding supports ongoing investment and interventions by local authorities across the United Kingdom to improve school food choices and facilities. A variety of changes, identified through a needs and capacity audit at the start of the study, were introduced. Many of these required little financial input, with their success being attributable to a willingness to rethink and revise existing processes. The interventions undertaken yielded a range of physical and temporal effects: improving food choices; reducing queuing times; improving the dining ambience; and increasing time available for physical and social activities.

Changes to eating and dining routines were associated with moderate improvements to learning-related behaviours of adolescent pupils in the post-lunch period. The observation of more on-task and fewer off-task behaviours indicated that pupils in the intervention schools were generally more

Table 3 Likelihood (OR) of on-task and off-task learning behaviours in intervention schools compared with control schools, by social-mode, taking potential confounders[a] into account

On-task behaviours	*Odd ratio*[a]	*Lower CI*	*Upper CI*	P
All settings	1.18	1.05	1.33	0.005
By setting				
Individual on-task	1.24	0.97	1.58	0.088
Pupil–pupil on-task	1.04	0.86	1.25	0.716
Teacher–pupil on-task	0.82	0.64	1.04	0.103
Off-task behaviours				
All settings	0.86	0.75	0.98	0.021
By setting				
Individual off-task	0.88	0.68	1.14	0.321
Pupil–pupil off-task	0.87	0.71	1.06	0.171
Teacher–pupil off-task	1.03	0.78	1.36	0.820

Abbreviations: CI, confidence interval; OR, odds ratio.
[a]Statistical analysis adjusted for class size (<22 vs 22 or more), presence of additional adults in the classroom, English as an additional language, sex, free school meal eligibility, special educational need status, ethnicity and lunch type (school meal or packed lunch).

alert and attentive than pupils from control schools at the end of the study. The moderately strong evidence suggested that this was the case, particularly when pupils were working alone. This observation is in contrast to our earlier study in which primary school pupils were observed to be more on-task when interacting with a teacher and less on-task when either working alone or interacting with other pupils after a similar intervention (Golley *et al*., 2010), and suggests that the increased alertness and interactivity attributable to modifications to the food and dining environment is manifested differently according to the age of the pupils. It may also reflect different types of interactions related to age-specific teaching modes or classroom layout (see Baines *et al*., 2003; Hastings and Schweiso, 1995). Younger children were more engaged when interacting with a teacher, but were more distracted when working alone or with other pupils and may require a more didactic approach. Adolescents, on the other hand, tended to be more engaged when working alone.

The changes in classroom behaviour observed after modifications to the eating and dining environments support the associations between academic performance and dietary intakes observed in cross-sectional studies (Kim *et al*., 2003; Florence *et al*., 2008). Greater attention in class and engagement in learning activities are likely to be associated with productive learning outcomes and better academic achievement. The mechanism for the observed effect on learning behaviour may be related to the physiological effects of improving nutritional status as observed in previous research on attention, memory and cognitive performance (Wesnes *et al*., 2003; Ingwersen *et al*., 2007; Benton and Stevens, 2008; Micha *et al*., 2010), but the effect may also be attributable to a combination of mechanisms. Changes to the dining environment, which improve service flow or enhance the eating environment, also facilitate both physical and social activities. By meeting students' needs in this way, the school eating and dining environments may facilitate informal peer relationships, which support the development of autonomy, competence and the wider benefits of 'release' (from study and from behavioural constraint in the classroom); for example, those developing from team sports or other group physical activity. Unpublished data from our research group suggest that, for adolescents, the balance between 'refuelling' and 'release' is a key determinant of their perceived quality of the lunchtime experience.

Traits such as autonomy and competence have been shown to influence older adolescents' engagement and achievement at school. Zimmer-Gembeck and co-authors observed that adolescent females whose needs are better met within the school environment are more engaged in the classroom, more attentive and interested in class and that this is related to academic achievement and length of their school career (Zimmer-Gembeck *et al*., 2006). A recent Canadian study also supports the benefits of a positive social-emotional learning environment for encouraging engagement and reducing school dropout rates (Archambault *et al*., 2009). Furthermore, social experiences during breaktime and in the classroom have been demonstrated to predict academic performance and classroom behaviour (Flook and Repetti, 2005; Barros *et al*., 2009).

Both the social and health aspects of participation in physical activity at lunchtime may contribute to improved learning behaviour and outcomes. A meta-analysis (Sibley and Etnier, 2003) showed a positive association between physical activity and cognitive performance in school children aged 4–18 years, and several studies have now demonstrated either positive associations between physical activity and academic performance or, at the least, no detrimental changes in academic performance following school-based interventions to increase physical activity (Taras, 2005; Hillman *et al*., 2008; Trudeau and Shephard, 2008; Chomitz *et al*., 2009). Further work is required in this under-researched area to confirm the observed associations and to investigate combined diet and physical activity interventions on educational outcomes.

The benefits of the observed greater on-task activity on learning outcomes are twofold. First, as discussed above, increased concentration and engagement can potentially improve learning outcomes and attainment. Second, the observation of less class disruption and reduced off-task activity indicates that behaviour improved during the post-lunch period, a time in the school day that, traditionally, has been problematic for effective classroom management. If the observation of improved behaviour during afternoon classes is shown to be reproducible, then improving diet and dining environments could effectively reduce teaching downtime and disciplinary issues.

Strengths and limitations

This study followed the Medical Research Council guidelines for conducting complex intervention trials (Campbell *et al.*, 2000). It used a pre-tested, valid, systematic, direct-observation protocol to record behavioural outcomes rather than indirect measures. Furthermore, a large number of observations were made per student over 5 days to enhance the interpretability of the data. Observers underwent extensive training and inter-observer reliability was high.

Observations were made in a wide variety of academic subjects across the arts, science and humanities, but owing to timetabling and other issues, it was not possible to stratify observations on individuals according to subject type. It may well be that the levels of engagement and autonomy vary within and between disciplines according to a range of factors including individual preferences, abilities, peer group influence and teaching styles. *Post hoc* analyses that controlled the variation in the subject mix across the sciences, humanities and expressive arts/technology yielded ORs that slightly improved the associations observed in the model reported above, from an 18% improvement in on-task behaviour (OR 1.18, CI 1.05–1.33) to a 22% improvement (OR 1.22, CI 1.08–1.37). This suggests that the effect on behaviour reported here has not been inflated by a biased sampling of classes across disciplines.

A possible limitation of the current study is the inability to distinguish the effects of the dietary and dining room modifications. These two aspects of the intervention may have independent, antagonistic, additive or synergistic effects. Although, in principle, a factorial design may have yielded more interpretable results, in reality, this would have been impracticable. The Primary School Study carried out, before the present study, attempted to assess the diet and dining environment components of the intervention independently, but the enthusiasm of schools for the 'make-over' and the need to reinforce acceptance of dietary changes by addressing environmental limitations meant that the dietary and dining modifications were made in tandem, precluding independent assessments. Indeed, the successful introduction of dietary changes is often dependent on environmental changes as a way of engaging pupils and encouraging acceptance of the changes made. Moreover, the continued promotion of school meal take-up by health agencies means that capacity issues will necessitate food interventions to be undertaken alongside logistic adaptations within the school environment. This means that independent delivery of interventions may be neither appropriate nor practicable in the real world situation.

Although the intervention was of sufficient duration to observe an effect on behaviour, a much longer study would be required to determine the sustainability of the behavioural changes observed and their impact on educational attainment, absenteeism, truancy and so on.

Conclusion

The results of this study are timely, given the recent introduction in September 2009 of mandatory nutrient-based school food standards for secondary schools in England and the government's focus on improving learning-related behaviours (Steer, 2009). It provides positive evidence of the benefits of modifying children's school food and eating environments on learning-related behaviours. Further research is required to replicate these findings over a longer duration, and to relate the present findings to attainment outcomes.

Conflict of interest

The authors declare no conflict of interest.

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